L Blake

AIDS TO NAVIGATION

A Discussion of the Problem of Maps for Blind Travellers

by

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INTRODUCTION

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INTRODUCTION

The topic of this paper deals with a further extension of the concept of independent mobility of blind persons: the discovery of a new route and the exploration of an unfamiliar area.

Not so very long ago, when the problems of obstacle detection were foremost in our minds, it seemed helpful to consider problems arising in one of four cells of a two by two table: regularly occurring obstacles in a familiar or an unfamiliar environment, and obstacles occurring unexpectedly in either of these environments. For practical purposes, research emphasis was concentrated on the problems of obstacles occurring unexpectedly in familiar environments because it seemed reasonable to assume that of all likely situations this was the one the blind traveller had to deal with most frequently: the bicycle left standing against a house-wall, or the open manhole cover somewhere along the very familiar route to work. Now it is not intended to suggest that the millenium has arrived and that all these problems have been solved. But it does not seem over optimistic or unduly enthusiastic to direct attention today towards the next logical step up in blind travel: the independent exploration of new territory.

At present, when a blind person wishes to discover a new route or explore new ground, the chances are that he will ask a sighted friend to take him over the route once or twice, or perhaps even more frequently before venturing out by himself. At present, this blind person is perhaps not as exceptional as might be thought, for in my experience blind people of all ages are just as interested in breaking new ground as the sighted. All the same, such intrepid travellers must have tolerably good basic mobility to venture forth in this manner. No doubt there are some who do their exploring on the basis of some form of description or even a crude map. And it is about maps that it is proposed to talk here.

PART I

GENERAL CONSIDERATIONS

It is necessary to begin this discussion by specifying the problem and clearing up some terms. The problem posed in providing maps for blind people is one met with quite frequently in human engineering where the properties of a group of individuals have to be matched with the properties of a range of displays. The major criteria to be adopted when assessing the degree of success obtained in such a match are first the extent to which a solution improves performance and secondly the extent to which there is a measure of user acceptance.

Maps are a symbolic and much reduced presentation of reality. A map as used by the sighted is generally a spatial pattern of a part of our environment, presented two dimensionally with a wealth of shape, colour, and line coding as well as written names of towns, streets, etc. It is a symbolic abstraction making use of all sorts of conventions some of which may not even be made explicit: for instance, the width of roads bears no relation to the range of real width experienced and is almost vastly exaggerated with respect to other dimensions in a map. But once we are able to learn and accept these conventions, we are presented with a simultaneously displayed pattern which bears a considerable resemblance to our direct perception of the mapped district. Looking down from a hill, a tower, or better still an aeroplane, there is a sense in which it is possible to match the symbolism of the map with perceived reality. Furthermore, it is possible for some people at any rate, to obtain such a clear visual image of a pictorial representation that they can reinstate a memory image of the map seen some time ago and compare it with the scene in front of them.

Thus, for the sighted there is only the relatively small problem of learning the two dimensional conventions which have to be solved before he can match map and reality. For the sighted it is possible to obtain correspondence by aligning the two as it were. This in turn enables him to say "I am here in real space on the map. In order to get to my destination I have to follow such and such a route and will encounter this and that in succession". In navigational terms this is known as steering by fixes as distinct from steering by dead reckoning.

The point which needs to be made at this early stage concerns the crucial problem of being able to bring map and reality in correspondence, for however well we may plan a route from A to B with the help of a map we will be lost if we cannot reconcile key features presented on the map with those visible to us as we proceed. Again, this is relatively easy for the sighted, for one does not have to rely merely on a configuration of roads or streets since it is always possible to choose more prominent features as key items: churches, hospitals, public buildings, etc., are frequently shown on maps.

Over and above this method of navigating by fixes, i.e. by utilizing a succession of landmarks, we do make use of dead reckoning in one form or another, or perhaps one should say that some of us can, by having a general sense of the direction in which we want to go. To those who are able, there are all sorts of natural cues available to do this, of which a knowledge of the time of day and the position of the sun is the most obvious one, but the orientation of churches is a less obvious example. In practice, the sighted, whether they move through town or countryside make use of a combination of both techniques adjusting the mixture as a function of their skill as well as the richness of cues available by either means.

Another way of putting this has been suggested by Dr. Michael Beddoes. Effective map-utilization requires means to close the loop of information flow from reality to map, to reality and back to map.

We have thus already covered the main uses to which a map may be put: to plan a journey, to guide one along that journey, or by a reversal of that process, to help that traveller to locate himself when he has got lost. The crucial issues are the extent to which one has to achieve a symbolization, and the ability to relate the information presented on the map to that perceived in real space. And quite inevitably we have come up against the problem of specifying, identifying, and representing key-features, i.e. landmarks.

So much for the sighted. When we come to consider the blind it will be helpful to consider the totally blind for the moment only. Now there is quite clearly a sense in which it is true that a totally blind person is not able to perceive a simultaneously presented pattern or configuration by the senses remaining to him in the same way as a sighted person can. It must be said at once that it seems unwarranted to me to assume that some form of simultaneous space perception is completely ruled out: it is instructive to watch a blind person sort out the sound-patterns at a roundabout. But the great divide between the congenitally blind and the rest does become much more important when it comes to the conceptualization of spatial patterns, and the translation of a small tactual pattern to a lifesized pattern in real space. Now it may well be that this is a pseudo-problem and has little to do with blindness, and a lot with the inability of the sighted to get into the conceptual framework of those born without the mode of visual perception. But wherever the source of the difficulty, for the moment it is useful to recognize what appears to be a frequently confirmed observation (not to say a fact) that mere transliteration of sighted maps into a tactual form meets with considerable difficulties among the congenitally blind.

If the hallmark of visual perception is its simultaneous characteristic, that of tactual and auditory perception is their sequential nature. It was on these *a priori* grounds that the German psychologist V. Senden erected a monument of documentation to prove that the congenitally blind's concept of space was strictly speaking non-existent but that there might be a form of sequential conceptualization of space. If one equates spatial perception of conceptualization with visual perception of conceptualization there is no sense in denying V. Senden's thesis and it becomes rather trivial. But if one is prepared to accept on the one hand the proposition that the dominant mode of spatial perception of the blind is sequential while on the other hand conceding the possibility of conceptualizing patterns or configurations from sequentially obtained and conceptualized information, there seems little *a priori* grounds for sustaining V. Senden's *a priori* assumption. To use the crudest form of machine analogy: we know that a visual pattern can be recognized by analogue or digital computers, and in a digital computer much of the process of recognition is sequential. We know that blind people can play chess, and that they can handle the concepts of co-ordinate geometry. Now all this does not mean that the presentation of a map has to be *a priori* sequential, but it may mean that for some people a purely sequential presentation may have a great deal to recommend itself.

But we also know for a fact the difficulties of tactual perception even when the object to be explored is less than the span of a hand. There is every reason to believe that the concept of a straight line built up from tactual experience is tremendously difficult. Over and above all this we do know that for the majority of the adult congenitally blind, it is extremely hard to make the translation between any form of symbolic presentation and the real thing, but particularly so when we come to two dimensional surface presentation of three dimensional space. I understand that it is only relatively recently that text-books for blind school-children have included surface diagrams other than geographical maps. And only recently there was a letter in a British Journal (*New Beacon*, February 1966), in which a blind correspondent stated flatly that he could not understand how one can represent a six foot man in a six inch picture.

If there is a considerable problem about the manner of representing space symbolically for the blind there is a similar problem about the specification and recognition of landmarks. It is important to be clear about this: we know from observation of blind subjects covering familiar routes the extent to which they rely on well established landmarks of all kinds which are idiosyncratic as distinct from being commonly accepted. The problem is not that blind people cannot detect and use landmarks with experience. It is rather that of translating landmarks from a map to those encountered in real space, and to find a measure of communality so that maps, if constructed, can be made for and used by more than just one individual.

Now as long as we are restricting the discussion to town travel, it is not unreasonable to assume that the most permanent features to be encountered are blocks of streets and that it would not be a bad beginning to use these as our basic units. While it is true that much redevelopment is taking place in the hearts of many towns at present, it still remains true that for much of the area of a town the characteristics of blocks of streets are tolerably stable. What is more, in theory at any rate, they do provide detectable landmarks. That is not to say that there are no difficulties: in the first place it is not always easy to distinguish between the entrance to a drive leading to, say, a block of flats, and the end of a block proper. Angles other than right angles are sometimes difficult to detect, and curvature of pavements is very hard to deal with. Furthermore, there is the problem created by veering tendencies on broad pavements and when crossing wide streets; and there are innumerable difficulties encountered in sorting out the consequences of making certain turns: you are walking with the street on your right and the wall on your left and you have to make a right turn when you come to the end of the block, and before you step off the kerb. If you make your right turn and carry straight on, you will now have the wall on your right and the street on your left; it is a bit confusing, when your relationship to street and wall may provide you with the only cue for the moment.

What other cues are available? Most eminently the slope of the pavement you intend to walk on, and expected noises. We have reason to assume from the work of Cratty that the perception of slope is a pretty useful one. Furthermore, even if the texture and width of a pavement may be altered by the local authority, the slope is less likely to be affected. Noises from fixed sources, i.e. churches, factories, railway stations, as well as from moving sources, e.g. direction and volume of traffic, can, of course, be of considerable value. But most of them are less permanent than street blocks and all of them are subject to masking.

To recap.: the sighted by and large can make use of visual spatial maps which are analogues of real space. They can see both map and real space as simultaneously presented patterns.

Maps for Blind Travel

Terminology first. It is intended to talk about form, modality, content portability, detail, hardware and solution.

Form. Maps can be either spatial or verbal.

Modality. Maps can be presented either tactually or verbally.

Content. Maps can deal with either a route or a district.

Portability. Maps can be either large and used statically, or they can be small and lightweight and used while moving about.

Detail. One can display information with a range of detail, e.g. single line presentation of a street pattern *vs* noting every crack in each flagstone.

Hardware. There is a wide range of materials out of which maps of all sorts can be constructed.

Solution. Maps can be produced either by a process of transliterating sighted maps or by finding solutions specific to the blind users.

For the purposes of this discussion it is intended to stick to maps for general rather than for individual use without denying the usefulness of the latter.

The first point to make is that none of the five variables listed above are independent of each other, and that in some cases choice of one category may exclude a lot of other choices; verbal presentation is more likely to be useful for route maps than for districts; the choice of material for making spatial tactual maps may be crucial in facilitating comprehension. All the same sort of framework is useful to keep the discussion within bounds and it is proposed to stick to the one above.

Form. In principle there is clearly no difficulty for a sighted person in understanding what is meant by a spatial map for a blind person: you take the usual sort of visual map and reproduce it in some sort of raised form so that it can be felt. In point of fact, this is what has been attempted in the past with varying degrees of success by a number of organizations and, while much effort and ingenuity has gone into these transliterations, it is worth noting that we do not really know the degree of success obtained as distinct from the opinions voiced about them. The advantage of a spatial map is that it does represent the sort of spatial pattern which has to be negotiated in real space and but for one fact such a map could have all the advantages of a spatial map for the sighted: the difficulty arises from the fact that it is difficult to produce an equivalent range of coding richness for the tactual mode. In point of fact it looks as if we are here rather severely limited to a small number of widths of streets and a small number of textures, and we are probably very severely limited in the minimum scale which can be adopted. There are, as it were, purely technical difficulties as distinct from the more fundamental conceptual ones referred to earlier on.

A further great advantage of a spatial tactual map is that it is immediately communicable to the sighted. We are, for instance, working with some transparent material which can accept ink outlines as well as raised impressions. Thus, a blind person wishing to seek sighted assistance would be able to explain any difficulties encountered, and be in a position to obtain a "fix" by this means.

A verbal map is a rather more difficult notion to get across. But it is only necessary to refer to descriptive texts and to guide books to make the case easier to understand, or to recall how frequently on being questioned we describe a route to be followed in words. In particular, it seems worthwhile drawing attention to the area of guide books for rock climbing. For a climber glued to a rock-face is in a rather similar position to a blind person at a crossroad in that neither can see the route ahead and that for both the route has to be described in non-visual terms. In the same way, it is possible to specify a route verbally by a number of useful terms. By and large such a description is more applicable to routes than to districts, but even though basically sequential there is no reason *a priori* to restrict descriptive text type of maps to routes: it would obviously be possible to describe a district verbally.

The amount of detail into which one can go in a verbal map, as well as the layout of such a map are matters for future research. But it is already clear that one may need a combination between rather full descriptions to which one can refer when in trouble, and the simplest possible devices which can be used continuously.

Modality. There are only two major sense modalities left once vision is no longer available, hearing and touch. A spoken map must presumably be basically sequential and is most ideally suited for a route. But there is no reason why a district should not be described in spoken terms. The point to remember about speech is that it is a well established system of communication, that it can be immensely rich, that it is as ambiguous as it is rich, and that it is always paced in speed by the "sender": once the word is gone, it can be retrieved only by asking the sender for a repetition. Touch, on the other hand, imposes the most severe limitations of coding richness, tactual presentation can be simultaneous, and it can be explored completely under the subject's control. The main difficulties here apart from coding poverty, are the difficulties of reproduction and of interpretation. Simple raised line drawings can be reproduced quite well nowadays on thermofax devices. But most of these will take small sections only. On the side of interpretation we have the serious difficulties of being able to distinguish tactually noise from signal: the slight crease in the paper, the slightly untidy line, all these assume more weight when they have to be taken in sequentially than when they can be scanned in a simultaneous pattern.

Content. The distinction to be drawn here is between maps relating to a single route and those relating to a whole district with which one may become familiar or through which one finds the route. This is indeed the great point about a district map that allows the traveller to establish his own route with a great deal of individual choice, and with the possibility of introducing variations on the theme. The route map on the other hand can be so constructed as to remove almost every need to choose, plan or think by providing the traveller with a sequence of commands which if obeyed properly will take him from A to B along a prescribed route, following the appropriate side of the street, and crossing at selected spots. Now for some people one method may be preferable to the other, and this too is a rich field for research.

Portability. This whole idea of providing blind travellers with a form of portable map appears to be somewhat novel, but there is really no reason at all why they should not have maps in the same way in which the sighted carry town maps or ordnance sheets. A portable map is in essence a means of taking the load off one's memory, and on the grounds that blind travellers have really quite a lot on their mind already, there seems to be every case for trying to take some of the load off. The main point in making the distinction between static and mobile maps is to draw attention to the different constraints which have to be considered in form, content, and hardware considerations, as well as the amount of detail permissible. The main points to be born in mind are size, weight and accessibility. Ideally one does not need to place any limits at all on static maps, but portable maps ought to be capable of being read with a minimum of disruption of the ongoing movement (reorientation after a stop or a slight turning of the body can be quite a problem to our blind traveller). There may be something to be said for having the maps so that they can be read with one hand, or at least read with both hands simultaneously. Thus the material has to be fairly rigid and should be crease and weather proof. There is reason to believe that spatial maps should not be larger than the span of one hand, or that sections of folded maps should not be larger than that. Similarly, in the case of verbal maps one would want to go for material which could be made sufficiently stiff to provide inherent stability for reading on the move.

From an acceptability point of view there may be something to be said for carrying maps in coat or jacket pockets, etc., but one is inclined to think that so much education will have to be put into map reading in any case that one might be able to add some gentle persuasion to it with regard to acceptability.

Detail. The amount of detail to be displayed usefully on a map is basically a function of two variables: the user's capabilities and the limits set by the hardware configuration. Again and again, one has to stress that it may well turn out to be useful to have different kinds of maps to be used in conjunction and that some may have to carry more detail than others. This is done among the sighted as well, though it must be conceded that it is easier to ignore some simultaneously presented information in order to enhance other aspects than this would be in the case of a tactual spatial map: we are accustomed to shifting attention within a visual display and selecting that which we consider relevant.

Having said this one now has to find out the sort of details which may be relevant to blind travel, seek for means of coding them on the map, and establish whether they can in fact be used to facilitate blind travel. At present we are inclined to go for minimal amount of detail: apart from indicating the difference between main streets and minor roads, for instance one would want some indication of the direction of slope if not of its extent. It may well be desirable to agree on codes to denote certain fixed sound sources as well as the configuration of one way streets (this is useful not only as a sound landmark, but also for purposes of increased safety in crossing streets).

The problem of street names is a hard one. Clearly if one wants to use braille for all names, this will set a lower limit to the size of spatial map one can have. It may be possible to restrict street names to a few major roads, or to introduce some form of number coding which could be sorted out by means of a brailled index. If one could have a grid system as a form of "overlay" for the map, this again might help, but it might use up one crucial bit of coding, i.e. a particular width or texture of line.

From the point of view of usefulness, it is worth remembering that by and large, one is looking for a reasonable degree of redundancy of information so that the blind person could orient himself without sighted help if lost. Say that I can specify the length of a block, the direction of slope and the texture of the pavement, and say that the traveller knows that he should take the fifth turning on the left of his route to get into this block. Now as soon as he does his left turn, he may get two cues to tell him that he has done the right thing: pavement texture and direction of slope. But if all the roads on the left tend to go up, he may require the texture and distance cue to be certain.

Hardware. The important distinction to keep in mind here is that we are dealing either with verbal or spatial material. The verbal material can be dealt with by braille, raised letters, or by means of a tape-recorder. We are dealing with braille for two reasons. First it is most likely that the class of people who will have difficulties with spatial maps is precisely the class that will have had training in braille, i.e. the congenitally blind. On the other hand it is prefectly open to us to attempt to use raised letters such as are used in King size Dymo tape. As far as static maps are concerned, it should be perfectly possible to produce a written version on ordinary sheets of braille paper. But if they have to be made portable we have to go in for material which does not crease, is weatherproof, can be used several times, can be folded, and can be read while on the move. Note that we cannot cope at this stage with a verbal-tactual map in cold weather because it then becomes hard to read braille.

But we can, and do, make use of a tape-recorder on which we record a route with suitably arranged material giving instructions and information for each section of the route. This is a bit elaborate, but there is little coding difficulty, and we can get a great deal of detail for each route.

Turning now to the spatial maps, it is important to make the distinction between static and mobile, and also between those maps which use surface presentation in the accepted sense, i.e. which are essentially transliterations of sighted maps, and those static maps which are essentially much more like three dimensional models. These range at present from the rather elaborate models used at Ovingdean and Hethersett to the rather simpler forms of models used by the Guide Dog Association.

When we come to portable spatial maps these will have to be made of material of similar properties to those described for the verbal maps, but much more generally the importance of establishing good methods of surface presentation has to be studied very much more carefully. There are a large number of variables that have to be investigated and these range from the nature of the raised line, its grittiness, whether there should be a continuous line or a dotted line, what kind of grittiness to dottedness one can distinguish, and the whole range of tactual coding. We therefore enter into the dimension of tactual discrimination for all these spatial maps and it is important to remember that the main features which we can introduce are depth and texture differences. That is to say any outlines that we wish to represent either streets or blocks of houses can be made to differ from the background in the extent to which this presentation is raised from the background, as well as in the surface texture. Now it seems quite reasonable to expect that the more dimensions of discrimination we can introduce the better the understanding or the comprehension of the presentation is likely to be. There is enough evidence of this from general studies of perception and there is no reason to assume that tactual perception will differ in kind. There is already some evidence from observation to suggest that a dotted raised line is rather easier to perceive and understand than a smooth raised line. It may very well be that that is due to the fact that one is now dealing with a difference in two dimensions, the line is raised from the background and it has a different texture from the background.

One should presumably make use of both height and texture cues whether one is using a model map or a spatial map. For tactual perception by and large has to be sequential. In order to understand what one is experiencing at any given moment one has to relate the present to the past. And the more reference one has to the past, the easier this process becomes. Therefore, a model map in which the streets are indicated by pieces of cardboard or lino which differ from that background solely by being raised from the background by, say, a quarter of an inch, could lead to confusion (as has been observed) once the subject's finger comes away from the edge, the one and only cue at his disposal, as subjects trying to trace a road may get on to the surface representing the block of houses rather than the road, and become lost, or at least lose the sense of continuity. If, however, one has used multiple texture coding to separate out street, pavement and houses, there is a much lower likelihood of confusion arising.

This does not exhaust all the problems involved in hardware considerations. For instance: when we come to consider verbal maps and we bear in mind that we want to have portable maps which convey a fair amount of information which can be handled unobtrusively by the traveller, we can see that there is a good case for putting such maps into a form of hardware which can be "concealed on the body", either in a pocket, or in a handbag, or under an overcoat. It does look therefore as if some form of circular verbal map, either on a continuous belt, or on a circular slide rule might be worth exploring if the basic idea of a verbal map does indeed appear to be feasible. We are currently experimenting with a number of ideas of putting forms of verbal maps into different hardware configurations, but on the whole we are concentrating on discovering more about the general feasibility of verbal maps.

Solution. The great advantage of transliteration of sighted material is that it enables us to make maximum use of material which is already widely in existence, and that it facilitates communication with the sighted. Thus, a district map which is portable and retains all the sighted features but has raised outlines as an additional feature is clearly desirable, and what is more, it can be used with perhaps less training than most of us would have thought. The great advantage of the special solutions is that there may well be lowered resistance to the acceptance of such solutions by the blind and that they ought to be more readily usable. Again, the answer is probably in a combination of the two approaches.

Reversibility. It is important to remember as far as district as well as route maps are concerned that people not only set out to go from A to B, but that as often as not they have to go back from B to A. In a map of a district, particularly of the spatial kind, this does not present any problems, because it is presumably as easy to trace the route from B to A as it is to trace it from A to B. But as soon as one has specified route map, difficulties may arise because the best route from A to B may not simply be the mirror image of the route from B to A. One may overcome this difficulty in one of two ways. One may either take care to construct routes in such a way that they are directly reversible, even though it may mean some translation of the coding symbols employed. Or else one may have to provide return routes as quite a separate item.

Orientation in Space—The Interface Problem

Having picked a route either from a district map, or from a route map we are now faced with the problem of relating the information on the map to the situation which we encounter, and more particularly to the sequence of situations. In other words, we want to obtain a sequence of fixes and to navigate ourselves from one fix to another. Enough has been said in the earlier sections to make it clear that this is a relatively simple task for the sighted. It is, however, very much more difficult for the blind, for there is a very real sense in which the landmarks which are most easily available to the blind have to be inferred to a large degree, rather than recognized. In fact, in many cases it will be extremely difficult to make a definite identification. This problem of the identification of a landmark, and of relating the position of that landmark to the position on the map, of identifying one's location in space, and on the map, is one of the key issues of the map reading problem by blind travellers.

This is the problem referred to by Dr. Beddoes as closing the loop. Say that the input to the system is the information provided on the map and that the desired outcome is a successful conclusion of the journey. At any given moment one can compare map information and reality information to carry out corrections and update the system. Under the open loop system one would steer solely by the information provided from the map, using direction and distance information. A completely closed system would make use of whatever relevant information could be presented symbolically on the map, recognized from the environment, and compared. Blind travel at present is a fairly inadequately closed loop system. Our task is to enrich the information flow.

Consider then, that a blind subject has a route sorted for him which is essentially a succession of street blocks, and that whenever he comes to the end of a streetblock, he has to take one of a number of possible actions.

He knows, for instance, that he has to turn right at the fifth turning. Strictly speaking, although he may know the name of the road along which he walks and the name of the road into which he has to turn, he has no means of identifying it other than by the fact that he has crossed four streets previously, (one is at present talking not about a familiar route where there may be other identifying landmarks but about a new route encountered for the first time), if we can provide him with additional information about slope of road, distance since the last block, etc., etc., we may be in a position to give him more cues to help him to identify the turning to the right. But the crux of the matter is that when the subject does come to one of the key landmarks he may not be able to identify it directly. Of course if the subject knows the name of the street concerned he may ask for sighted assistance to obtain a fix, but one has to keep reminding oneself of this crucial point, that unaided the chances are very low that the subject is able to identify the key landmark in the same way in which the sighted subject is able to identify this and relate it to the map.

This leaves one with the possibility of knowing one's position simply on the basis of the sequence of events which has gone before, and this in turn makes it important to be sure of the nature of that sequence on the one hand, and the other hand to be sure that on whatever form of map has been used, one does not lose one's place in the sequence.

In a type of verbal map which we have been using, and which consists of nothing but a sequence of orders about actions to be taken at the end of blocks, we have provided the subject with a cursor which he can move along a strip on the cane or the handle of a guide dog, or along a sort of hand-held cursor, whenever he has carried out an action. This therefore separates future actions from past actions, and in a crude way indicates the position of the subject along his route. We know that in principle this method of route indication works, but it is clear that it is only an inferred method of identification and that other means of establishing correspondence with real space have to be used as well.

For portable spatial maps we have hardly any observational evidence as yet, but it does seem to be possible to use them in a manner not entirely different from the verbal route map described above. It does seem to be possible, at any rate, for rather intelligent blind youngsters to keep reorienting the spatial map in such a fashion that the lines used to represent the road along which they are walking are always pointing down their bodies. It appeared equally possible on the trial for these youngsters either to remember their position on the map, or to keep their finger on it in much the same way as the cursor is kept in position along the strip mounted on the cane. Alternatively the boys can be provided with a district map, plot out a course by putting small pins along a suggested route, and use a moving pin, differently shaped, to keep their place as they move along. If now, by means of use of sun or compass, the subjects can be provided with an indication of north, south, east and west, we may be going a long way towards teaching the use of maps to blind people.

ON MAP CONSTRUCTION

One now has to consider the person constructing the map and the manner in which such a map can be constructed. It is clearly desirable that maps, if they are at all useful—and this still remains to be seen—should be easily available to blind persons. Therefore, their mode of construction should be such that they can either be provided for local requirements from a central pool, or else, that they can be constructed easily locally. Such construction may in the main have to be carried out by sighted people but it would clearly be useful if some kinds of maps could be constructed by blind people from dictation by the sighted, or that route maps could be produced from spatial district maps. It is here that verbal maps may probably have something to be said for them. In principle it is certainly possible to make the kind of verbal map already described by various standard ways of brailling, and this can be done by the blind person himself.

Whatever form, modality, or content are chosen, it is clear that one has to develop a somewhat specialized language or coding system. This is clearest so far in verbal maps where the terminology chosen describes landmarks and critical features in terms which are relevant to the blind. Not every blind person will readily use the same terms to describe identical landmarks. But here a certain amount of unification, brought about by training, may well go a long way towards solving some of the presently intractable problems. For if all blind people could come to use something like a common language for orientation, this would enable them to ask for directions from the sighted in a more constructive way.

But over and above this, when it comes to the construction of maps, there is clearly a certain skill involved having regard to the particular problems of blind travel. In the case of district maps one may wish to indicate special dangers and safe crossings, while in route maps care has to be taken to "steer" the traveller along routes with unambiguous landmarks and avoiding certain obviously dangerous crossings. This may mean taking the traveller apparently out of his way in order to achieve this, but this is not very different from the custom followed by the designers of route maps for the motorist: it is quite common practice to have such routes follow main roads, even though they may involve longer distances, either because main road travel is generally easier, or because it is often much more complicated to be directed along a series of minor routes.

PART II

In this part of the paper, I want to describe some of the maps which we have already constructed and are using with small groups of blind people, using the classification proposed earlier. Next I want to describe briefly some of the work going on at the moment, (Summer 1966). Finally, I want to end by drawing attention to the problems which this phase of the work has enhanced.

Table 1 shows the extent to which some of the possible cells have already been filled.

Table 1

		Static	Portable
SPATIAL	*District*	*RNIB London* *WCB Town* tactual med. detail paper or plastic transliteration (sections can be portable and produce combined district and routes)	*Chartpak Town Map* tactual med. detail paper transliteration
	Route	*Leamington G.D.* *Model Map* med. detail (side of st.) tactual, draught excluder, specific. (main use = mediation)	*Chartpak single line* tactual medium detail (pattern and side of street) plastic transliteration specific
VERBAL	*District*	Nil	Nil
	Route	Nil	*Venetian Blind* tactual high detail (could have more) mixed material specific *Tape Recorder* auditory max. detail mag. tape recorder specific (can be used by sighted) *Memorizer* tactual, minimum detail mixed (plastic, metal etc.) specific (Braille or big Dymo letters)

Beginning with a good example of a spatial, district, static map there is of course the well known map of London produced by RNIB. This shows the main roads of London in bold relief.

With the co-operation of J. Pickles, Esq., of Worcester College for the Blind, a large map of the whole of Worcester was produced. A commercially available town plan was enlarged to a scale of 12 inches to the mile, and a mirror-image print obtained. A spurred wheel was run along all the roads, river lines, etc. This produced a raised positive image on the other side of the photograph. This map was mounted on plasterboard and made available to users in this form.

Two 10 × 10-in. sections of this map were cut out and reproduced by a thermoform process. The copies turned out to be better than the original.

A portable equivalent was produced by taking a commercially available town plan of Nottingham and covering the street lines with transparent Chartpak, $\frac{1}{16}$ in. wide. The scale is approx. 14 ins. to the mile. This produces a tactually perceptible street pattern leaving the printed street names still visible through the tape. A small number of fixed landmarks, e.g. town centres, bus stations, were indicated by braille letters made with Dymo tape.

A well known example of a spatial, route, static type of map is the sort used in the guide dog training centres, though in some cases these may embody more than one route.

We have made various versions of model maps as described in the *New Beacon* of February, 1966. We use strips of plastic draught-excluder prepared to have an L-shaped cross section: the shallow piece represents the pavement, the high piece the wall or house side of the pavement. These strips are then laid out to cover a predetermined route, showing one side of the street only, i.e. the one along which one is walking.

A portable equivalent of this was produced using single line Chartpak strips to indicate the route pattern. By arranging for side roads to be represented by short strips coming in from that side of the street along which one is supposed to walk, and one or two similar conventions, it is possible once again to indicate the side of the street along which one is supposed to walk.

As far as verbal maps are concerned, we have so far worked with portable route maps only. It will be recalled that all route maps share the feature that one represents the whole route as a sequence of identifiable sections, and that one tries to provide some form of structure to enable the user to keep his place in this description as he goes along.

The first high detail version of this is referred to as the Venetian blind because of its physical appearance: each section is described by one row of information, with six columns in each row. The first column is simply a running number. The second gives the name of the street one is walking along. The next the side of the street, the fourth whether one is going up, down, or level; the fifth the distance in feet to the end of the block; and the last column shows the order appropriate to the action to be taken at the end of that block, e.g. turn left on the upkerb. When a street has to be crossed, the name of that street appears on a row by itself. Each row is mounted on a lightweight metal strip $\frac{1}{2}$ in. wide and about 9 ins. long, and all the rows are mounted on a flexible piece of Holland. This means that one can carry the map around in a rolled up state when it is not required. The user can keep his place by the current number, the name of the streets, and the action order in the last column. This column corresponds exactly to the entries on the memorizer (see below here) which it was thought might be used together with the full map.

Tape Recorder: Going a bit further, and following a firm suggestion from J. Burnett, of the Leamington Guide-Dog Centre, we have produced a number of spoken route descriptions and recorded these on a small Grundig EN3 tape recorder. Here the route is described in a succession of orders, the beginning and end of each order coinciding with a section as before. But it is possible with this technique to describe several simple sections in one order. Each order begins with two 300 cycle tones. Then comes the number of the order. This is followed by the name of the road junction which one has reached plus the direction into which one is facing. The next part contains the instructions about what to do, followed by more detailed information about the side of the street one is walking and the direction in which one is going. There may also be information about other peculiarities of the section. All this is followed by a single 300 cycle tone. After this comes a repetition of the basic instructions, the end of order call sign and a further two 300 cycle tones. If the user wants to listen to the basic instructions again, he simply rewinds until he hears the single tone, now a short pip at 900 cycles. If he wants to go right back to the beginning of the order he rewinds until he hears the double pip. This method allows one to provide the user with very detailed information indeed. The spoken word is simple enough to understand, but one needs some practice to be able to comprehend some of the conventions adopted. Again, we think that this may eventually be used in conjunction with a memorizer.

The memorizer idea was also first described in the *New Beacon* of February, 1966, but has since been much improved. In its current form it consists of a disc of about 3 ins. diameter. This disc is divided into sixteen sectors. Each sector can carry three dymo brailled letters: in the outer ring we have put the basic action order: e.g. p = turn left on the upkerb. The ring below tells the user the side of the street he should be on in terms of either X or Y, and this is given only in those sectors where there is a change of side: thus if the user stays on the same side of the street for six blocks he can tell this at once from the fact that the second ring is blank for five segments. The inner ring is available for hazard warning, e.g. this is a roundabout, look out for grass verges, noisy mainroad, etc.

Mounted concentrically with this disc is a cursor assembly. This consists of a knurled knob with a thin pointer attached. The movement of the knob is controlled by a springloaded ball bearing fitting into a circle of sixteen holes. The pointer locates itself in a position midway between segments. The user moves this cursor on after every action in order to obviate having to remember the sequence of actions and to keep his place on the disc. In other words, the cursor separates the past from the future. Where the Venetian Blind and the Tape give a great deal of detail, the memorizer provides the absolute minimum. The disc can be operated with one hand. It can be carried in one hand, on a loop round the shoulder, or put into one's pocket and operated there.

Note that the cursor assembly is entirely self-contained. This means that one can have a number of different discs, each with a particular route on it, but that one needs only one cursor assembly to fix on to any given disc.

Ongoing Work

During the past 6 months, work has been going on with some of the maps described with members of our research panel at Nottingham, with guide dog users under training at Leamington, and with boys at Worcester College for the Blind.

At Nottingham we have a very suitable test site situated in a Victorian housing estate with every desirable and undesirable natural cue. There is usually not a lot of traffic about, but this is something we could easily arrange for if desired. Here we have tried out most of the maps listed earlier. With a group of some six cane and dog travellers we have gone quite a way towards de-bugging two versions of the memorizer, the tape-recorder, and the Chartpak town map. On the basis of experience gathered here, we discarded the Venetian Blind map for the time being though it was shown to enable some of our subjects to locate themselves.

At Leamington we began by using two versions of the memorizer with tolerable success over both familiar and totally unfamiliar routes. We are continuing here with the tape recorder and this too shows rather greater promise than expected. At Leamington we also have an opportunity of asking subjects to give us opinions about various forms of route and district maps of familiar and unfamiliar territory. Note that here we have to tailor our investigations to the very tight requirements of an ongoing training scheme so that we can only take up very little time per subject. The procedure adopted for the present is that we see subjects for four sessions. Two during their third week of training, and two during their fourth week. In the first of each pair of sessions the subject is taken over the route in the classroom by means of a model map of that route, and whatever device we are trying out is explained in conjunction with that map. During the second period the subject is asked to walk the route. In the third week of training we deal with a route which is at least partially known, while in the last week we tackle a completely unknown route.

At Worcester we started by comparing the memorizer with the first spatial portable route map on record. While the memorizer came out quite well (and was liked by the boys because it obviated the need to think), we were so impressed with the boys' ability to handle spatial route and district maps that we have been concentrating on this all last term. Each of six boys had given to him a copy of a section of the big Worcester map, mounted on plasterboard. We picked the beginning and end of a route on either side of the area covered, and asked the boys to plot their own course through the network of streets. They did this by putting pins into successive "choice points". So far this was no more than a finger maze exercise. The boys were then taken out to the starting point and asked to get to the goal. They were given one extra pin to act as a movable marker so that they could "know" where they had got to on the map. They were also told about the use they might make of the sun (if present). On the whole, the results have been sufficiently encouraging for us to contemplate doing this kind of work on a larger scale during next term.

At Worcester too, the boys were shown the map of the whole of the town area and asked to find their way from the College to the centre of town by using their fingers. Again this turned out to be rather more successful than anticipated.

Perhaps the most exciting suggestion to have come from all this work has been the possibility of teaching blind children geography in much the same way as it is taught to the sighted: i.e. by beginning with maps of very familiar areas such as their home town or the school and allowing them to make a comparison between their already existing knowledge of the spatial relations of that area and a diagramatic representation. It should be pointed out at once that much of this is only possible as a result of recent hardware advances, i.e. the advent of plastic materials.

Main Conclusions

The main conclusions from the work of the past 6 months is that almost all the methods we have tried have enabled some of our subjects to walk along new routes, under our supervision, but with relatively little intervention on our part. It seems fair to say that the majority would not have been able to do this without these aids, though there are undoubtedly some blind users who achieve remarkable feats of memory in route work. The higher the degree of residual vision, the better this tends to be, what is a bit remarkable is the relatively low degree of residual vision which appears to make a good bit of difference even here.

As far as the boys at Worcester are concerned, they may well be getting rather better ideas about the concepts of scale and space, and about the relationship between symbolic presentation of space and the real thing.

Most of the errors which subjects make are not directly due to map reading as such. They are due either to sloppy mobility drill and a reluctance to take in and make use of the information available. By sloppy mobility drill is meant for instance the kind of movement which causes a user to walk off a kerb in the middle of the pavement and think that he has come to the end of the block when a little care could have avoided it. By reluctance to make use of information available is meant for instance the failure to detect the consequences of bad drill: a veering crossing brings one to a pavement sloping down when the information presented makes it clear that one should now be going uphill.

I hope that I will not be misunderstood here, for I know quite well about the difficulties and the tedium of blind travel. It is navigation in the presence of pretty constant risks and in the absence of most of the relevant information. To do it efficiently requires more or less constant attention to excruciatingly petty-fogging details. The cues are few, and they have to be taken in, recognized, and used sequentially and with a high sampling rate. I know, because I have seen some very good and some very poor performances. I sympathize fully when my subjects tell me that it is really much easier to ask people the way because this is what I prefer to do myself.

The point to make however, is this: some form of map reading by the blind is quite definitely on, it is a credible and a viable proposition. But it has to be paid for by a measure of standardization of mobility drill so that users can be brought into positions where they can encounter recognizable and specifiable landmarks, described in a commonly accepted language. And it also has to be paid for by a willingness to make use of the information which can be provided. That information, in all conscience, is everything else but redundant in character, and therefore every little bit has to be made to count.

OUTSTANDING PROBLEMS

1. First and foremost there is the interface problem but to which Dr. Beddoes has given a much better term: how can we turn map reading from an open loop system into a closed one? At present much of blind navigation is open. The memorizer exemplifies this, for in a very real sense with this device by itself the blind person knows where he has got to not by a comparison of real space with a pattern on the map, but by the position of the cursor which divides the past from the future. It is very difficult for the blind person to obtain enough information from the environment, it is very difficult for us to present it in a usable symbolic form in our maps, and it is very difficult to relate the real and the symbolic.

2. So the next problem is that of developing a good language and a good coding system. We have adopted a good deal of the Guide Dog language because these people do already have a useful language to describe mobility situations and there is an existing user population familiar with it. We are only too happy to adopt other forms of language if and when they look like being useful.

3. This leads to an intriguing third point: the notion of having a single common language and coding system for all blind users, whether they use

guide-dogs or canes. Now there are obviously difficulties about this because these two groups differ somewhat in their choice of orientation cues. Consider two examples. Guide-dog orientation is based on the drill that the dog comes to a stop at each downkerb, and that the whole system is in a sense based on the use of downkerbs as landmarks. The cane traveller on the whole prefers to cross in the middle of pavements because this tends to avoid some of the consequences of accidental veering and because it may often be the safer thing to do with regard to traffic. Again, the guide dog user on the whole is more concerned about knowing on which side of the pavement he can expect to have traffic, while the cane user tends to be more concerned with the side of the pavement which has walls, fences, and houses.

4. Next in this list of problems one should return to the two different types of solution: transliteration or specific solution. This is clearly a matter for experiment and experience. The advantage of transliteration is that it is in many ways more desirable because it makes use of material already in use for the sighted, such as the town maps I have mentioned. It helps communication between the sighted and the blind. There are, however, still some quite serious problems of hardware and of training. For there are only relatively few among the congenitally blind population who have had much experience in the handling of line diagrams unless they have gone through schools fairly recently.

The advantage of the specific type of solution is that it is probably more readily accepted by the blind user population on a short term basis. We tend to think increasingly of the specific type of solution in its role as a mediating device in training to handle transliterations. For instance, the model map appears to be preferred by blind users over other forms of maps, but it also helps to achieve more ready acceptance of forms of transliterated route maps. Similarly we think that one of the main uses of the tape recorder may well be in introducing blind users to the idea of organizing routes, of asking for information and obtaining descriptions of routes in a more standardized form.

Looking ahead a bit, it is eminently clear that other forms of instrumentation would be very useful as navigational aids. The ultra aid for instance may well turn out to be maximally useful as a distance perceptor of landmarks and as a straight line travel aid. Indeed, some form of straight-line travel is clearly the next item of hardware that one would like to see arrive on the scene. Some indication of orientation is needed not merely in order to avoid veering at street crossings, but also to enable the traveller to maintain his general forward direction when this is needed. It was therefore with great interest that we learned of the work which had been done in this field by Dupress at the Sensory Aids Evaluation and Development Center in Cambridge, Mass. Attention is drawn in particular to the importance of having the direction indicator strapped to the body rather than in the hand. It is to be hoped that these efforts will lead to a small device, attached to the body, which can give the traveller desired direction has come to the end of the block when a little care could have avoided it. By reluctance to make use of information available is meant for instance the failure to detect the consequences of bad drill: a veering crossing brings one to a pavement sloping down when the information presented makes it clear that one should now be going uphill.

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SUMMING UP

To sum up, I will just make the following points:

It seems perfectly possible for blind people to make use of suitably prepared maps for routes and of districts. Like everything it will require training, and not every blind person will be able to use maps. But then the sighted have to learn how to use maps and there are a good many among them who do not know how to do so.

Arising from this work, there may well be some more general consequences beginning with the possibility of blind youngsters being able to have an introduction to geography not so very different from that of their sighted contemporaries, by starting with maps of their own, known home and school environment. And quite apart from the specific purposes of increasing independent mobility of the blind, the use of maps could well help to increase their general knowledge of the world around them. It is also very likely that the use of maps will be yet another means of facilitating contact between the blind and the sighted.

There is also the more theoretical usefulness in that this work might help to increase our understanding of the use of spatial concepts by the blind.

Lastly, it seems to me that the work I have been reporting on is a good example of collaboration in partnership between practitioners, users, and research workers. All the maps which we are now using retain a small modicum of ideas which I happened to inject. They have become flesh and blood, so to speak, as the result of working with the practitioners and the users who have produced most of the good ideas. I, in turn, was lucky enough to have the facilities to try out these ideas.

Thanks are due to the Medical Research Council for providing the financial and general support, the blind members of our research panel, the staff and students at Leamington, and at Worcester College for the Blind.